GSI Enhancement for Variational / Ensemble Cloud Assimilation - Work Plan

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1. Ming tests if the GSD repository can be accessed through Yellowstone. If yes, then, we can build a GSI trunk on GSD repository. This repository will be synced with EMC RAP GSI branch all the time for consistence and for in-time merge the RAP development back to the EMC trunk. Based on this GSD RAP GSI repository, many branches can be created for cloud analysis enhancement development, for RAP/HRRR GSI development, and for NARRE development. Ming created a new GSD repository trunk called narre. Terra created a branch of the narre trunk for her cloud analysis work and learned the process of merging with the trunk.
Need to get repository access for all collaborators: EMC, NCAR-MMM, OU/CAPS

2. In Sept 2014, Ming created a ticket for this work in EMC GSI wiki.

3. Generalize the background and observations I/O for all GSI applications (RAP, NAM, GFS) (need to work with Shun, Haidao and Terra also need to involve.)

a) This is technical goal to generalize background for ARW-Thompson microphysics. Add cloud ice number concentration to GSI I/O. New GSI bundle code to handle background I/O changes needs to be brought into GSD repository. A table (namelist) file is used to describe the fields in background file. Ming merged the new GSI bundle code into the narre trunk. Terra added cloud ice number concentration and cloud water number concentration (Thompson microphysics in WRF version 3.6) to the I/O for GSI. These variables can now be updated in the cloud analysis. The updates were tested with both netcdf and binary I/O. Additional testing is needed to determine how the number concentration should be updated for the case of building clouds.
b) This is technical goal to generalize cloud observation interfaces for all GSI (GFS, NAM, RAP/HRRR), which will be used for current cloud analysis and future VAR analysis. Observation (i.e. radar) data needs to be GSI read with bufr obs file and handling mapping to analysis grid space. Prefer obs-processor to handle vertical interpolation but will need access to model background file. NESDIS and NASA Langley satellite data handled inside and outside GSI respectively. NCEP Langley data merged into single bufr file with multiple time-valued field within the data file. Need more information on the satellite data types. Need to merge several data files from NASA into one global data bufr file. Developed code to read goes-east and goes-west bufr data from NASA. Began development of global satellite observation processing (goes-east, goes-west, meteosat-10, mtsat-2/himawari-7) from NASA.

4. This task is like 3a, but for GFS. Extend GSD cloud analysis function for GFS application, mainly on how to divide total water from GFS into cloud water and ice and then how to merge analyzed cloud back to total water. Also, how to get the other background fields (Temperature, moisture, pressure) from GFS for the cloud analysis? (Ming work with Haidao). For testing, Haidao need to build GDAS system on Zeus.

Development in GSD cloud analysis (Terra and Ming):

The GSD cloud analysis actually gets the cloud liquid water first based on temperature, moisture, and pressure, then divide the cloud liquid water into cloud water and ice based on the temperature. When use

GSD cloud analysis for GFS, we can use the cloud liquid water directly because GFS has only total water. Work plan for GSD cloud analysis for GFS application:

A. We found the GFS total liquid water is actually the cloud water plus the cloud ice. So there are no need to divide it into cloud water and ice because the original analysis results are cloud liquid water in GSD cloud analysis.
B. Terra will create a GFS cloud analysis driver based on currently ARW cloud analysis. GFS cloud analysis driver will only keep the cloud analysis part and delete (comment out) all precipitable hydrometeor part.
C. Terra and Ming will add code in the GFS cloud analysis driver to read in temperature, moisture, pressure, height from GFS analysis results.
D. After GSD cloud analysis generates analyzed cloud liquid water, update the total water and moisture and temperature in GFS.
E. Because GFS/GDAS prepbufr have no cloud observation. Ming needs to develop the code to merge the RAP prepbufr into the GFS/GDS observation (turn off the surface T, Q, UV observation first). GFS cloud analysis only has observations in N. America in the test.

5. First task for moving towards VAR analysis.

a) Add cloud control variables (qi and qc) in GSI (Terra, Ming) for background.
b) Also, if we make the background BE variance large, the only impact for cloud analysis is from cloud observation operator and results should be similar to current cloud analysis. We need to construct the observation operator with general interface for portability.
c) Get static background BE including cloud water and cloud ice from MMM (Tom, Gael). This task will take more time… might be done after other tasks.

6. Initial attempt for the VAR observation operator is to avoid creating a complex observation operator. Instead, run GSD cloud analysis to create cloud water and cloud ice observations based on the real cloud coverage (retrieval). Use these retrieved cloud water and cloud ice as observations to do var-cloud analysis in GSI. (Terra and Ming). This step is to simply the cloud observation operator and let us focus on BE and var-cloud analysis impact.

7. Run RAP retro tests with var cloud analysis and compare to the GSD cloud analysis. (Terra and Ming)

8. Improve var-cloud analysis (Terra, Ming, Tom Auligne (NCAR), Gael Descombes (NCAR)) by,

· Merge the cloud cover from GSD (based on METAR and Cloud Top Products) and Tom (based on cloudy radiance) to improve the cloud coverage, special cloud between cloud top and bottom.
· Add new recursive filter in vertical to contain the cloud analysis increment within the cloud cover area. Also try to use cloud coverage to tailor cloud analysis increment.
· Test and tune the balance among cloud water/ice analysis increment and moisture, temperature, etc to improve the cloud retention of the 3D cloud.

9. Develop new observation operator for cloud observations (METAR and satellite cloud top). After this, no need to run GSD cloud analysis for cloud analysis. May still need for precipitation. CAPS has Precipitation Var-analysis and plan to add into GSI. If add these into GSI, we can do both cloud and precipitation var-analysis.

10. Use either global DA ensembles or RAP regional DA ensemble with GSI hybrid to test cloud analysis with ensemble BE for improving the cloud assimilation.